

- 1 -

CIGARETTE MANUFACTURING MACHINE AND

Inventor A1
CONTROL SYSTEM THEREFOR

This invention relates to the manufacture of filter cigarettes and to control systems for controlling the cigarette rod making and filter tipping machines.

Cigarette rod making machines and filter tippers are well known. Commonly, cigarette rods made by a rod maker are passed automatically to a filter tipper over a transfer apparatus. The filter tipper adds a filter to the cigarette rod and wraps tipping paper around the combination. The finished cigarettes are then passed to a packaging station.

More recently, production speeds have been increased by manufacturing double length cigarette rods. These double length rods are transferred to the tipper as a whole. As part of the transfer process, the cigarette rod is split at its mid-point, the two single rod lengths separated and a double length filter inserted between the separated rod length. Tipping paper is wrapped around the whole and the filter is then cut at its mid-point to produce two completed cigarettes. As these cigarettes are arranged in the tipper in opposite directions, one of the cigarettes is then rotated before the completed product is passed to the packaging machine.

Traditionally, cigarette manufacturing machines have been essentially mechanically driven and controlled. The various motion/rotating devices in the machines are driven through appropriate gear boxes from a main drive. In recent years there has been a move to replacing some of this bulky drive train with a series of independent servo motors which are synchronized with one another.

We have appreciated that there are many aspects of the cigarette production process which are not controlled adequately by existing machinery.

The present invention aims to address the above-mentioned deficiencies in the prior art.

- 2 -

According to the invention there is provided a cigarette manufacturing apparatus comprising: a tobacco rod maker for making double length tobacco rods; a tipper for applying filters to tobacco rods to form filter tipped cigarettes; a transfer apparatus for transferring double length tobacco rods from the rod maker to the tipper; wherein each of the tipper and the rod maker comprises a plurality of devices for monitoring and/or affecting parameters of the rod maker, the tipper or the cigarettes being manufactured; a controller for controlling the plurality of devices on the tipper and the rod maker; and a field bus, the plurality of devices and the controller being connected to the field bus.

The invention also provides a cigarette manufacturing apparatus comprising: a tobacco rod maker for making double length tobacco rods; a tipper for applying filters to tobacco rods to form filter tipped cigarettes; a transfer apparatus for transferring double length tobacco rods from the rod maker to the tipper; wherein each of the tipper and the rod maker comprises a plurality of devices for monitoring and/or affecting parameters of the rod maker, the tipper or the cigarettes being manufactured; a first controller for controlling the plurality of devices on the tipper and the rod maker; and a second controller for providing tipper, rod maker, and cigarette information to an operator and for communicating input data from the user to the first controller.

The invention further provides a cigarette manufacturing apparatus comprising: a tobacco rod maker for making double length tobacco rods; a tipper for applying filters to tobacco rods to form filter tipped cigarettes; a transfer apparatus for transferring double length tobacco rods from the rod maker to the tipper; a plurality of synchronised servo motors each for driving a respective operation in the tipper or the rod maker; wherein each of the tipper and the rod maker further includes a plurality of devices for monitoring and/or

- 3 -

5 affecting parameters of the rod maker, the tipper or the cigarettes being manufactured; a motion control device for controlling the plurality of synchronised motors; a system controller for controlling the plurality of devices on the tipper and the rod maker, the motion control device being connected to the system controller; and a field bus, the plurality of devices and the controller each being connected to the communications network.

10 In one embodiment of the invention it is preferred that the synchronised motors are servo motors. Preferably, the communications network is a field bus-type network.

15 The invention also provides a cigarette manufacturing apparatus comprising: a tobacco rod maker for making double length tobacco rods; a tipper for applying filters to tobacco rods to form filter tipped cigarettes; a transfer apparatus for transferring double length tobacco rods from the rod maker to the tipper; wherein each of the tipper and the rod maker comprises a plurality of devices for monitoring and/or affecting parameters of the rod maker, the tipper or the cigarettes being manufactured; a control network, the plurality of devices being coupled to the control network; a first controller connected to the control network for controlling the plurality of devices on the tipper and the rod maker; and a second controller coupled to the first controller and including at least one HMI for providing tipper, rod maker and cigarette information to an operator and for communicating input data from the user to the first controller.

20 The invention also provides a method of controlling the manufacture of cigarettes by an apparatus comprising a tobacco rod maker and tipper interconnected by a rod transfer apparatus, the method comprising the steps of: providing a field bus and a machine controller connected to the field bus; connecting a plurality of devices to the field bus, for monitoring and/or affecting parameters of the rod maker, the tipper or the cigarettes being

- 4 -

manufactured; monitoring the field bus from the controller for data from the devices; and adjusting one or more parameters of the tipper or rod maker in accordance with the information content of the data received.

Embodiments of the invention have the advantage that the entire cigarette manufacturing process is controlled as a whole. In the prior art, the rod makers and the filter tippers are controlled individually which we have appreciated is undesirable. Preferably, devices to be controlled in both the rod maker and the tipper are all linked on a common field bus which is controlled by a common controller. This has the advantage that machine wiring is minimised yet permits improved communication between devices on the fieldbus and the controller.

Preferably, both the tipper and the rod maker have human machine interfaces (HMI's) which can receive data from and send data to the fieldbus via the controller. Preferably, the HMIs are controlled by a different controller from the devices on the field bus. The control data may be accessed, for example, through a TCP/IP link to a factory local area network (LAN) or beyond enabling remote diagnostics. The separation of the data ensures that the integrity of the manufacturing process can not be compromised, for example through unauthorised users on the LAN.

Embodiments of the invention have the advantage that production speeds may be greatly increased. Embodiments of the invention have the advantage that many adjustments may be made to the machine without stopping production which would hitherto have required substantial down times. For example, the phasing of the maker to the tipper. When ramping up to full speed the phasing can be changed during ramp-up to give a higher quality cigarette during this time. In addition the ratio of the garniture belt to the suction tape can be varied to allow different brands having different parameters to be manufactured without

- 5 -

stopping the machine. The position of the manufacturer's print information on the cigarettes can be varied according to defined parameters as can the position of the densed end in the tobacco rod. This facilitates a switch 5 of production to a different brand with different brand specifications. By eliminating the majority of the mechanical linkages and replacing these with intelligent devices such as intelligent servomotors, and distributed control, quieter operating may be achieved which is 10 beneficial to users of the machinery.

Embodiments of the invention have the additional advantage that there is a greater mean time between failures and, in the event of failures, there is a smaller mean time to repair. The mean time to repair is partly 15 reduced by the presence of the HMI which has access to diagnostic data from devices on the field bus enabling quick fault diagnosis and quick identification of faulty components for replacement. In addition, diagnosis may be made from a remote site, for example over the factory 20 business LAN or Intranet.

An embodiment of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a schematic view of a front end of a 25 cigarette rod maker showing the hopper arrangement of drums and rollers which transfer tobacco to the suction chamber;

Figures 2 and 3 show schematically a hopper suitable for use in the cigarette rod maker of figure 1;

30 Figure 4 shows schematically one embodiment of a roller for use in the hopper of figures 2 and 3;

Figure 5 is a schematic view of the suction chamber showing apparatus for controlling the rod density;

- 6 -

3 Figure 6 is a schematic cross section of the apparatus of figure 5 on the line 6-6 in figure 5;

Figure 7 is a detailed view of one embodiment of part of the apparatus of figure 5;

5 Figure 8 is an exploded view of the apparatus of figure 7;

Figure 9 is a detailed cross sectional view of a second embodiment of the apparatus of figure 5;

10 Figure 10 is a schematic view of the maker from the suction band to ejection of completed double length rods;

Figure 11 is a perspective view of a transfer apparatus showing a kicker used to transfer rods from the rod maker;

15 Figure 12 is an enlarged view of a portion of the apparatus of figure 11;

Figure 13 is a plan of the kicker assembly of figure 11;

20 Figure 14 is a front view of the assembly of figure 13;

Figure 15 is a plan of the kicker wheel;

Figure 16 is a front view of the kicker wheel;

Figure 17 is a section A-A of figure 16;

Figure 18 is a plan of the suction housing;

- 7 -

Figure 19 is a front view of the suction housing;

Figure 20 is a rear view of the suction housing;

Figure 21 is a schematic view of the drum assembly of
the transfer apparatus of the cigarette manufacturing
machine embodying the inventions;

5

Figure 22 is a rear perspective view of a transfer
apparatus with the cover removed;

Figure 23 is an exploded view of parts of the
transfer apparatus;

10

Figure 24 is a perspective view of the receiving drum
of the transfer apparatus;

Figure 25 is a perspective view of the suction
housing for the receiving drum;

15

Figure 26 is a perspective view of the tipper;

Figure 27 is a front schematic perspective view of
the rodmaker with the positions of certain motors
shown;

20

Figure 28 is a rear schematic perspective view of the
rodmaker with the positions of certain motors shown;

Figure 29 is a rear perspective view of the tipper
with the positions of certain motors shown;

25

Figure 30 is a schematic view of a first embodiment
of the control system for the tipper and rod
manufacture showing the field bus;

- 8 -

Figure 31 is a schematic view of a second embodiment of the control system for the tipper and rod manufacture showing the field bus;

5 Figure 32 is a view of the main menu displayed on the tipper HMI;

Figure 33 is a view of the prepare maker screen displayed on the maker HMI;

10 Figure 34 is a view of the parameter adjust screen displayed on the maker HMI;

15 Figure 35 is a view of the phase shift screen displayed on the maker HMI;

Figure 36 is a view of the prepare tipper screen displayed on the tipper HMI;

20 Figure 37 is an overview of the relationship between various screens displayable on the tipper and maker HMIs;

Figure 38 is a flow chart indicating the major steps in the control process;

25 Figure 39 is a flow chart of showing the steps in the general start up routine;

Figure 40 is a flow chart showing the steps in the tipper start up routine; and

Figure 41 is a flow chart showing the steps in the maker start up routine.

25 The basic operation of the cigarette rod making machine and the tipper will first be described.

- 9 -

The cigarette rod making machine manufactures double length cigarette rods and transfers these to a tipper which further cuts the double rods and inserts a double length filter between the rods. Tipping paper is then applied and the finished cigarette pairs are severed, alternately re-oriented, tested and sent for further processing.

Figure 1 shows, schematically, the front end of a tobacco rod maker. This is only one example of the front end of the maker and other front ends may be used. Cut tobacco is fed initially into the back of a hopper 10. A top mesh drum 1, which has a vacuum drawn through it, carries the tobacco to a paddle wheel 2 which closes the hopper well. A sensor 3 in the hopper well detects whether there is a sufficient quantity of tobacco in the hopper. The vacuum to the mesh drum 1 is turned off when the hopper sensor 3 is covered by tobacco and is switched on when the sensor becomes uncovered. A guard door 4 is provided at the top of the hopper through which tobacco recovered from spillages etc. may be added. A tamper plate 5 is fitted in the hopper well which is pushed into the well at regular intervals to stop the tobacco from becoming compacted. A permanent magnet 6 is fitted under the paddle wheel 2 to remove any ferrous material from the tobacco stream.

The hopper may be of purely conventional design as shown in figure 1 or, modified as shown in figures 2 to 4. In the hopper of figure 2, a spiked metering roller 7 located at the bottom of the hopper well carries the tobacco from the hopper dropping it in the area behind a pair of carded drums 8,9 which will be described in due course.

In the hopper of figures 2 to 4, a delivery roller 12 is disposed across the inlet of the hopper. The circumferential surface of the roller 12 has spikes 14 to engage with tobacco entering the hopper. In one embodiment of the machine the roller 12 is mounted on a

- 10 -

driven shaft 16 and comprises four separate roller sections 12a,b,c,d. At the bottom of the hopper the two rotatable carded drums 8 (only one drum is shown) are disposed. Between the level of the delivery roller 12 and the carded drum 8, in a location corresponding to the desired maximum level of tobacco in the hopper, a generally horizontal row of four photo sensitive cells 20a,b,c,d is disposed. Each cell 20a,b,c,d is connected to an actuator for a respective roller section 12a,b,c,d, and each cell is at a point in the hopper wall vertically below the projection of the respective roller section onto the hopper side wall.

In use, tobacco enters the hopper 10 from above. All the delivery roller sections 12a,b,c,d rotate to distribute incoming tobacco onto the rotating carded drum 18 which forms the floor of the hopper. This situation, shown in figure 2, obtains so long as the level of tobacco in the hopper remains below the level of all the photo sensitive cells 20a,b,c,d. Figure 3 shows a hopper 10 in which the level of tobacco 22 has risen to the desired maximum level adjacent two cells 20b,d. Activation of these cells by the tobacco causes them to send a signal which disengages the respective roller sections 12b,d, which causes less tobacco to be distributed to the regions of the hopper 10 covered by the activated photo sensitive cells 20b,d.

Once the level of tobacco has fallen below the level of the activated photo sensitive cells, the disengaged roller sections are reengaged and rotate, distributing tobacco to those regions once more. If desired, re-engagement of roller sections may be delayed for a fixed time after the respective photo sensitive cell is deactivated, allowing the level of tobacco in the region monitored by the activated cell to drop below the desired maximum.

The signal sent by a photo sensitive cell on activation can cause the respective roller section to

- 11 -

engage the driven shaft in any of several ways. For example, the signal can cause an electromagnetic clutch within the roller section to engage the driven shaft, causing the roller section to rotate. Alternatively, the 5 signal can cause a solenoid to move a key in one of the shaft or the roller section into a keyway in the other; the relative rotation of the driven shaft and the unengaged roller section will bring the key and keyway into opposition so that engagement takes place.

Figure 4 shows a pneumatic clutch arrangement. A 10 delivery roller 12 comprises four roller sections 12a,b,c,d (the spikes of the roller are not shown). The driven shaft 16 on which the roller 12 is mounted has passageways 24a,b,c,d each of which opens in the circumferential wall of the shaft 16 away from the roller 12 and each of which ends in an actuator chamber 26a,b,c,d which opens in the circumferential wall of the 15 shaft 16 adjacent a respective one of the roller sections 12a,b,c,d. Each actuator chamber 26a,b,c,d houses a friction block 28a,b,c,d which engages sealingly with the side walls of the chamber 26a,b,c,d but is free to move in the chamber toward and away from the respective roller section 12a,b,c,d. In the embodiment shown, two of the channels 24a,b open in the circumferential wall of the 20 shaft 16 to one side of the roller 12 and two to the other side.

A source of compressed air (not shown) is connected 25 to each of the passageways 24a,b,c,d by air supply pipes 30a,b,c,d. The supply pipes 30a,b,c,d are connected to the passageways 24a,b,c,d in such a manner that the shaft 16 can rotate without rotation of the supply pipes. The connection may be such that each supply pipe 30a,b,c,d is in constant communication with a respective passageway 24a,b,c,d throughout a revolution of the shaft 16. This 30 can be achieved by providing a plenum block 32 circumferentially around the shaft 16 through which the 35 air supply pipes 30a,b,c,d pass. The ends of the supply

- 12 -

5 pipes adjacent the shaft each end in a respective circumferential plenum chamber 34a,b,c,d, each of which is in constant communication with the respective passageway 24a,b,c,d as the shaft rotates. Alternatively it can be that the communication is broken as the shaft rotates, the open ends of the channels being sealed during the rest of the revolution of the shaft by means not shown such as sealing blocks extending circumferentially around the shaft 16 through which the 10 air supply pipes 30a,b,c,d pass.

10 In use, when no signal is received from one of the sensors 20a, indicating an acceptable level of tobacco in the part of the hopper covered by that sensor, a valve (not shown) in the respective air supply pipe 30a is open admitting air under pressure into the circumferential plenum chamber 34a in the plenum block 32 and thence into the respective passageway 24a in the rotating shaft 16 and the actuator chamber 26a at the other end of the 15 passageway 24a. The raised air pressure in the actuator chamber 26a urges the friction block 28a in the actuator chamber 26a against the wall of the respective roller section 12a, causing it to rotate with the shaft 16.

20 If the sensor 20a sends a signal indicating a build up of tobacco in the part of the hopper covered by that sensor, the valve in the air supply pipe 30a closes. The air pressure in the actuation chamber 26a returns to atmospheric as air leaks out of the passageway 24a, so that the friction block 28a is no longer urged against the wall of the roller section 12a, thus disengaging that 25 roller section from the shaft 16 so that the roller section stops rotating. It will be appreciated that the other roller sections 12b,c,d are disengaged and engaged in the same way in response to a signal or the lack of a signal from the respective sensors 20b,c,d in the hopper.

30 The signal from the activated cell can pass through a processing device which then sends a signal to the respective roller section. It will also be appreciated

- 13 -

that the cell may be activated to send a signal when it is not detecting tobacco, and cease to send the signal or send a different signal when it detects tobacco.

Referring back to figure 1, the tobacco metering roller 7 draws tobacco from the hopper 10 creating a constant head. The metering roller 7 is controlled by three photo electric sensors (PECs) 36, 37, 38 which are arranged such that the metering roller speed is increased if any of the three sensors cannot see tobacco, so ensuring a constant head.

From the metering roller 7, tobacco is passed between the carded drum rollers. The upper of those rollers 8 is a small carded drum and the lower a large carded drum 9. The lower, large, carded drum 9 picks up the tobacco and carries round until it meets the small carded drum 8. These drums rotate relatively slowly and are synchronised to the main drive. The gap between the two carded drums allows a uniform quantity of tobacco to pass through. Excess tobacco is formed into a roll by the contra-rotation of the two carded drums. The tobacco is then passed to a pair of picker and winnower rollers 41, 42 which rotate at a relatively high speed and throw the tobacco into an air stream to transport it to an suction band. The picker roller operates by picking tobacco from the large carded drum 9 and passing it under the winnower roller 41 which accelerates the tobacco to a perforated rotating collector tube 43. Suction passing through the collector tube 43 picks up the tobacco and carries it round into the airstream passing up a chimney 44. Air from a small fan is blown up a scroll 45 fitted under the collector tube which blows the strands of tobacco up the chimney. Heavier particles of tobacco, stem and birdseye fall through the airstream into the stem collector 46. Air is also sucked up the chimney by a large fan which pulls the strands up to a perforated band. The velocity of the air can be altered by reducing

- 14 -

the air flow entering the chimney. The velocity of the airflow is altered to suit the product being used.

The hopper section has a synchronised drive controlling the large carded drum and a variable speed drive controlling the tobacco metering roller or delivery bands, which can have a variable set point dependent on the machine speed.

The tobacco passed up the chimney is held on the underside of a suction band which carries it forward to a garniture. The depth of tobacco held on the band is 10 trimmed by ecreteur discs to the correct depth.

Referring to figures 5 to 9, an endless suction band 47 passes longitudinally through the chamber 40 in the direction shown by the large arrow in figure 5. The suction band 47 is preferably driven by a servomotor synchronised with the other motor drives and is permeable to air but substantially impermeable to tobacco. Alternatively it may be mechanically linked. The chamber 40 has a top wall 49, a bottom wall 49', side walls 15 50,50', and end walls 48,48'. The bottom wall 49' extends from the downstream end wall 48' of the chamber 40 toward the upstream end wall 48, but stops short. A downwardly extending wall 51 depends from the upstream edge of the bottom wall 49' and defines together with a downward extension 52 of the upstream end wall 48 of the chamber, a chimney 54 through which tobacco is introduced 20 into the chamber. The side walls 50,50' are substantially parallel to the longitudinal axis of the chamber 40. The end walls 48,48' are substantially transverse to the longitudinal axis of the chamber 40. The suction band 47 enters the chamber 40 through an entry port 56 in the end wall 48 and leaves the chamber 40 through an exit port 56' in the end wall 48'. A fan 25 (not shown) is provided to draw air through the chimney 54 and the suction chamber 40; tobacco is fed to the chimney and entrained in the air.

- 15 -

A rotary stepper motor 58, which includes a gearbox, is disposed outside the suction chamber 40 and attached to a side wall 50 of the chamber 40. The spindle 60 of the motor 58 passes through a hole 62 in the wall 50 of the chamber 40. The motor 58 is attached to the wall 50 of the chamber 40 so that the spindle 60 is free to rotate and so that no oil leaks from the motor 58 into the suction chamber 40 through the hole 62. The free end 64 of the spindle 60 is in the chamber 40 above the suction band 47 and above the bottom wall 49'. The free end 64 of the spindle is connected to the mounting end 66 of a finger 68 extending radially outward of the spindle. The free end 70 of the finger 68 contacts the upper surface of the suction band 47. An ecretEUR 72 is situated below the suction band 47 and after the end 70 of the finger 68. A density determining means downstream of the suction chamber 70 determines the density of newly made tobacco rods (not shown) by a conventional beam attenuation method and sends a control signal to a weight control computer and thence to the motor 58.

Figure 7 shows in detail a first embodiment of the finger 68 and the motor 58. Figure 8 is an exploded view of the components of the finger 68 and the motor 58 of the embodiment illustrated in figure 7.

The free end of the finger 68 defines a segment of a circle so that the surface of the finger 68 that contacts the band 47 is curved. This finger shape has been found to prolong the life of the suction band 47. Preferably, the surface of the finger 68 that contacts the band 47 is hardened or has a hard insert. More preferably the surface of the finger 68 that contacts the suction band 47 is nitrided or coated with tungsten carbide or ceramic.

The finger 68 is mounted on the motor spindle 64 by a bolt 74 passing through an open ring 76 at the mounting end 66 of the finger. A tolerance ring 78 fits between the open ring 76 and a housing 80 by which the motor 58

- 16 -

is attached to the wall 50 of the suction chamber 40. An O-ring seal 82 between the housing 80 and the chamber wall 50 prevents air or tobacco passing between the housing and the chamber wall. A U-cup seal 84 between the motor spindle 60 and the housing 80 prevents oil leaking from the motor 58 into the chamber 40 and prevents tobacco entering the motor 58. Screws 86 attach the motor 58 to the housing 80. Screws 88 attach the housing 80 to the wall 50 of the chamber 40. A reference point sensor (not shown) is disposed above the finger 68 and an over rotation sensor (not shown) below the finger 68.

The motor may be of any type but is preferably a stepper motor or other proportional actuator device such as a solenoid actuator or LVD device.

Figure 9 shows in detail a second embodiment which is similar to the embodiment of figures 7 and 8 but in which the finger 68 is coupled to the motor 58 and gearbox by an extension shaft 90. An end 92 of the extension shaft 90 is hollow and accommodates the spindle 60 of the motor 58. The extension shaft is attached to the motor spindle 60 and extends from it towards the wall 50' of the chamber 40. The other end 94 of the extension shaft 90 passes through the open ring 76 at the mounting end 66 of the finger 68. A cap 96 fits over the end 94 of the extension shaft 90 and abuts the mounting end 66 of the finger 68. The cap 96 is attached to the extension shaft 90 by a screw 98 that passes through the cap 96 and into the end 94 of the extension shaft 90. The cap 96 ensures that the finger is retained on the extension shaft 90. In this embodiment, the housing 80 of the motor 58 extends into the chamber 40 through the hole 62 in the wall 50 towards the other wall 50' to form a hollow cylindrical sheath 100. The extension shaft 90 passes through, and extends beyond the hollow cylindrical sheath 100. The distal end 102 of the hollow cylindrical sheath 100 (relative to the motor 58) is adjacent to a

- 17 -

tolerance ring 104 mounted on the extension shaft. The tolerance ring 104 seals the gap between the distal end 102 of the hollow cylindrical sheath 100 and the mounting end 66 of the finger 68.

As in the first embodiment, the O-ring seal 82 prevents air or tobacco passing between the housing 80 and the chamber wall 50. A U-cup seal 106 between the extension shaft and the hollow cylindrical sheath prevents oil leaking from the motor 58 into the chamber 40 and prevents tobacco entering the motor 58. It will be appreciated that the motor spindle and the extension shaft are protected from the abrasive effect of tobacco by the hollow cylindrical sheath 100, the tolerance ring 104, the mounting end 66 of the finger 68, and the cap 96 which together cover the motor spindle 60 and the extension shaft 90.

In use, the suction band 47 is driven by the synchronised servomotor unidirectionally so that it moves relative to the suction chamber 40 in a direction parallel to the longitudinal axis of the chamber in the direction shown by the large arrow in figure 5. As the suction band 47 is driven, air is drawn into the suction chamber 40, by means not shown, through the chimney 54. Tobacco (not shown) entrained in the air is drawn onto the suction band 47 upstream of the bottom wall 49'. Excess tobacco drawn onto the suction band 47 is removed by the ecreteur 72 driven by a synchronised servo motor. Tobacco remaining on the suction band 47 after trimming is formed into a continuous tobacco rod. The density determining means measures the density of tobacco in the newly made tobacco rod by the conventional beam attenuation method. If the density of the newly made tobacco rod is too high, the density determining means sends a signal to the motor 58 and causes the motor 58 to rotate the spindle 60 clockwise (as the spindle is viewed along its axis towards the motor 58). Rotation of the spindle 60 causes the finger 68 to rotate and the free

- 18 -

end 70 of the finger 68 to move clockwise (viewed as before). Clockwise movement of the free end 70 of the finger 68 causes it to move downwards towards the ecreteur 72. As the end 70 of the finger 68 moves towards the ecreteur 72, the suction band 47 moves towards the ecreteur 72. Movement of the suction band 47 towards the ecreteur 72 increases the amount of tobacco cut away by the ecreteur 72. Consequently, less tobacco remains on the suction band 47 than before and less tobacco is delivered by the suction band 47 to make the tobacco rod, which is thus less dense.

If the density of the tobacco rod is too low, the density determining means sends a signal to the motor 58 and causes the motor 58 to rotate the spindle 60 anticlockwise (as the spindle 60 is viewed along its axis towards the motor 58). Anticlockwise movement of the end 70 of the finger 68 causes it to move upwards away from the ecreteur 72. As the end 70 of the finger 68 moves away from the ecreteur 72 the suction band 47 remains in contact with the finger 68 and moves away from the ecreteur 72. Movement of the suction band 47 away from the ecreteur 72 reduces the amount of tobacco cut away by the ecreteur 72. Consequently, more tobacco remains on the band 47 than before and more tobacco is delivered by the band 47 to the tobacco rod, which is thus denser. The continuous tobacco rod is cut into double length tobacco rods.

Each time the apparatus is switched on, the finger 68 is set to a reference position sensed by the reference point sensor. The reference position is chosen so that the amount of excess tobacco removed from the suction band by the ecreteur is approximately correct. If the finger rotates too far towards the ecreteur, the over rotation sensor sends a signal to the motor 58 which then resets the position of the finger 68 to the reference position. The finger is prevented, therefore, from operating for prolonged periods in the wrong position.

- 19 -

Referring now to figure 10, the linear speed of the suction band 47 is defined by the length of the tobacco rod of the cigarette to be made and the production rate of cigarettes. The densed end is formed just before trimming, this is done by a single rotating cam that compresses tobacco in the stream.

The cam 110 rotates at one revolution per two linear cigarette lengths of travel along the suction band. The ecreteur or trimming discs 112 are set so that their peripheral speed is slightly greater than the linear rod speed and the height of the tobacco stream with respect to the trimmer discs 112 is controlled by the weight control unit (not shown). Trimmed tobacco is returned to the hopper by, for example, a spiral screw and shaker tray transport mechanism.

The trimmed tobacco, with formed densed ends is then passed to a garniture 114 where the tobacco rod is made up. The garniture includes a belt driven by a synchronised servomotor which draws wrapping paper 116 from a bobbin. The stream of tobacco is deposited on this paper and the rod is formed by the shape of the garniture which wraps the paper around the tobacco stream. Adhesive from a reservoir is applied to the edge of the paper by an applicator nozzle 118, the adhesive is set by passing the rod under a temperature controlled heater bar 120. At this point, the machine is making a continuous cigarette rod with densed ends at either one tobacco or two tobacco lengths along it.

The cigarette wrapping paper fed into the garniture is drawn off the bobbin by a pair of pinch rollers. The average linear speed of the paper must equal the linear speed of the garniture belt. However, when a bobbin is exhausted it is necessary to stop the paper to splice automatically the next paper bobbin. To achieve this, the bobbin speed is increased before the splice to fill a paper reservoir to enable constant running of the rod maker during the splice operation. After the splice, the

- 20 -

bobbin speed is increased gradually to a linear speed just below garniture speed to exhaust the paper reservoir. When the reservoir is exhausted the paper speed will be increased until it again equals the garniture speed. The bobbin drive may be an independent servo drive which receives machine speed signals from the master axis drive on the machine and uses a further signal from a dancing arm to apply speed correction by sensing paper tension.

The cigarette paper is then passed through a printer on its way from the bobbin to the garniture at which stage manufacturer's information such as brand name is printed by a print wheel on the cigarette. The print wheel may have four impressions and is therefore controlled to rotate once every four rod lengths. The printer may have its own synchronised servo motor. This permits the print position to be advanced or retarded, to improve quality, not by changing the length of the paper run, as is done conventionally, but by changing the phase between the printer and garniture tape servo motors through software parameters.

The finished continuous rod is then passed to a knife cut-off unit 124 which includes a knife blade mounted on the periphery of a rotating drum. The drum is driven by a servo motor to which the linear drive speed is synchronised such that drum rotates once every two cigarette rod lengths so as to cut the rod stream into double length rods. It is essential that the cut is through the centre of the densed end. Thus, there is an exact relationship between the garniture belt drive, the dense end cam and the knife, both in relative speed and position.

The rod must be running at a constant speed with respect to the cutter otherwise the cigarette length will vary. However, as the cigarette length may vary, from brand to brand, changing the rod length is achieved by

- 21 -

changing software parameters which define the speed and position relationships of the respective servo drives.

The cutter includes a mechanical sharpening and deburring system to keep the knife blade sharp after each revolution. A knife advance mechanism maintains knife position replacing lost knife material during grinding and deburring operations.

The continuous rod is supported during the cutting operation by a conventional ledger 126.

Before the cut, the tobacco rods are passed through a nucleonic or other density measuring device 122. The rod density is measured electronically and any deviation from pre-determined limits will cause the band above the ecreteur discs to be raised or lowered accordingly. The rods then pass a sensor which causes the first few rods of a run to be ejected to maintain quality control. The rods then pass to a kicker wheel which accelerates the rods to a transfer apparatus for transfer to the tipper. The kicker rotates once per two cut lengths (that is per two double length rods) and its diameter is such that the rotational speed of the periphery is higher than the linear rod speed to achieve the acceleration. The kicker, shown in figures 11 to 20, picks the rods off the rail and transfers them to the receiving drum of the transfer apparatus. The kicker shown in figures 11 and 12 is a helical kicker and the kicker shown in figures 13 to 20 is an in-line kicker. Either may be used.

The receiving drum has a cover and receives rods from the kicker at high speed. The rods are received in flutes on the drum and decelerated and held by a series of suction holes along the length of the flutes. The flutes have flared ends to make it easier for the rods to be received from the kicker in the flutes.

The kicker assembly comprises a main housing 200 which is mounted on the rod maker. At an end of the housing is a drive 210 which is driven from the rod maker drive via a shaft at the far end of the housing (not

- 22 -

shown) through a timex pulley and belt (not shown). The drive transfers drive via a drive belt 212 to a second, kicker shaft 214. Both the drive shaft and the kicker shaft have toothed belt wheels 116 on which the drive belt is mounted. The belt 212 is retained inside a belt housing 218 to which is fixed a suction housing 220. The belt housing is pivotable about the drive 210 to set the kicker wheel at the correct height above the rod maker vee-rail. Attached to the belt housing is a bar 217 to which is fixed a guide plate 219. The guide plate is held above the vee-rail behind the kicker wheel and prevents the trailing ends of rods flicking up as the leading edge is picked up by the kicker wheel. It also acts to keep the rods in line. The suction housing is shown in figure 23 and comprises a solid flange having a central aperture 222 and a hub 224 which is connected to the belt housing. A suction passage 226 is formed in the periphery of the flange at a position between the central axis of the flange and the front face. The suction passageway passes through the flange to a suction reservoir 228 or the rear of the flange. The reservoir 228 is provided to ensure a constant suction as will be described. The reservoir 228 is connected to a suction pump (not shown).

At a position adjacent and slightly behind the suction aperture (in the direction of rod movement) is a second passageway 229. This passageway 229 is a rod release passageway and is connected to an air supply (not shown) at the rear of the flange, the rod release passage way 219 passing through the flange approximately parallel to the suction passageway. The air supply pushes air through the rod release passage way to break the suction applied by the suction passageway to release rods from the kicker.

Over the suction flange, which is static, is arranged a kicker wheel 230. The kicker wheel comprises a front face 232, a peripheral flange 234 and a hub 236.

- 23 -

The hub passes through the central aperture 222 of the suction flange and is fixed to the kicker shaft 214 for rotation therewith. The peripheral flange is not continuous but divided into two sections of equal length by a pair of flats 238. Each flange section has a groove 240 running along its length with a series of equally spaced holes 242 formed at the base of the groove. The grooves are arranged off the centre of the flange such that they overlie the suction and rod release passageways of the suction flange, and such that when mounted on the housing, the grooves overlie the centreline 250 (fig 13) of tobacco rods on the vee-rail of the rod maker.

In use, the kicker wheel 230 rotates above the rods on the vee-rail. The suction provided through the holes in the grooves picks individual rods from the rail and the rotation of the kicker wheel accelerates the rods towards the receiving drum. The reservoir in the suction flange ensures that the suction is maintained. As the suction is communicated through holes in the groove, the suction is effectively being switched on and off as the holes pass over the suction aperture. The reservoir mitigates against a loss of suction which might cause a rod to be released from the kicker. This is particularly important with double length rods whose increased weight requires a greater suction.

A rod will be released from the kicker when a flat on the kicker periphery passes over the suction passageway releasing the suction. However, there is a tendency for there to be some residual suction which can lift the tip of the rod. As can be seen from figures 10 and 11, the clearance between the flutes of the receiving drum and its cover is small and a raised tip could be damaged by the cover or, in the worst case, be prevented from entering the receiving drum causing the whole manufacturing line to break down.

The air blown through the rod release passageway ensures that any residual suction is broken and that the

- 24 -

tip of the rod is exactly parallel with the receiving drum flutes when it is released. This ensures that the rod is successfully transferred from the vee-rail to the receiving drum.

5 Referring to Figures 21 to 25, the rods from the kicker are passed to a receiving drum 334. Rods are introduced onto the receiving drum from a direction parallel to the axis of rotation of the drum.

10 Alternatively, a helical kicker could be used which would transfer rods in the same direction. The receiving drum is a fluted drum having 18 tapered flutes 336 around its periphery, each of which receives an individual rod from the kicker 332. The outer sleeve of the receiving drum is shown in figure 24.

15 A conventional receiving drum has 36 flutes. The 18 flutes of the drum 334 have mouths which are wider than conventional flutes facilitating transfer from the kicker at high speeds. It will be appreciated that to operate at 8000 cpm, the receiving drum must rotate at 222.2 rpm giving a capacity of 4000 double length rods per minute.

20 Each of the flutes has a tapered receiving end 338. which assists in guiding the rod into position. It will be appreciated that the angle of the taper may be selected to provide the best transfer within the constraint of having 18 wide flute mouths 340 around the periphery of the drum. Thus, the flutes are formed of two portions, a rod braking and holding portion 341 which is narrow and sufficiently long to hold a double length rod and a tapered portion 343 which is shorter than the rod holding portion and tapers from the mouth 340, at which it is several times the width of the narrow portion, to the rod holding portion.

25 The rods arrive at the drum from the kicker at high speed. The flutes include a row of vacuum holes 347 through which air is sucked to brake the rods and to hold them in position in the drum. Preferably, the vacuum holes extend along the length of the rod holding portion

- 25 -

into the tapered portion of the flute along the centre longitudinal axis 349 of the flute. This gives the operator maximum control of the rod and allows the rod to be controlled as soon as it enters the flute. The drum sleeve illustrated in Figure 24 is shown with the rod stops removed. The rod stops are fixed in place by screws held in screw holes 351 and their position is variable. The row of suction holes extends as far as the stop, the final hole 353 being enlarged. At the far end of the row of holes 347, each of the rows terminates in an elongated slot 355. The holes in the flutes, with the exception of the end holes 353, are threaded so that they can be blocked off to tune the flutes. It may be necessary, for example to reduce the suction for a less dense cigarette rod.

The flutes are of equal length and width. To receive a double rod, the flutes may need to be longer than those of a standard receiving drum. The portion of the drum which transfers rods is protected by a suction cover assembly 345 which assists in retaining the incoming rods in the flutes by creating an air flow channel between the flute and the cover 342. Preferably, the cover 342 is transparent. Cover assemblies are well known in the art and the present assembly differs from the prior art in that it is longer to cover the longer flutes and in that it is provided with a series of holes 361. These holes 361 can be seen from figures 11 and 12.

The stops at the end of the rod holding portions are positioned such that rods are aligned with their centres on the centre line of the transfer apparatus.

At the front of the drum is an internal rib 359 extending around the inner surface and having holes for attachment to a front plate.

The outer sleeve of the receiving drum is mounted on the suction housing which is illustrated in figure 25. The suction housing has an air outlet 390 which is connected to a suction pump (not shown) and four ports

- 26 -

392 which communicate with the suction holes in the flutes of the outer sleeve enabling air to be drawn by the pump through the suction holes and extracted through the air outlet 390, thereby providing the necessary suction to retard and hold tobacco rods in the flutes.

5 The suction ports 390 are arranged around the suction housing to ensure that adequate air can be drawn through the suction holes in the flutes along the entire length of the flutes. For that reason, the position of the ports 392 is staggered on the suction housing.

10 10 Rods from the receiving drum are transferred onto an intermediate drum 344. This drum also retains rods in 14 flutes by suction. The drum rotates at 285.7 rpm to achieve 4000 rods/minute operating speeds.

15 15 The flutes of the intermediate drum are sufficiently long to retain a double length rod. But, in contrast to the receiving drum, the entire rod length is not held in the flutes of the intermediate drum. Only a centre portion is held with the ends overhanging a cutaway at either end of the flutes. Thus, the flutes of the intermediate drum are considerably shorter than the rod holding portions of the receiving drum.

20 20 Rods are transferred between the receiving drum and the intermediate drum and then the other drums using picking techniques. This method is well known in the art and involves suction holding a rod in the flute of a first drum, releasing this suction at the transfer point enabling the rod to be transferred by suction onto a flute of the next drum where the suction in that flute retains the rod in position.

25 25 30 From the intermediate drum 344, the rods are transferred to a cutting drum 346 where the double length rods are cut at their medial point into two single lengths. The rods are then separated on a separating drum 348 and passed to a filter assembly drum 350. While on the filter drum, a double length filter rod is inserted from the tipper between the spaced apart rod

35 35 35 35

- 27 -

lengths. In the tipper, this filter is attached to the two rods and then cut to produce two finished cigarettes.

The cutting and separating drums are standard drums as used, for example on the Hauni Max-80 transfer apparatus. The filter drum may be a standard drum as used, for example on the Hauni Max-S transfer drum. No further description of these items is necessary.

It will be appreciated from the Figures that the receiving drum rotates in a clockwise direction. The intermediate drum picks out the rods from the receiving drum and is required to obtain the correct flow direction of the tobacco rod.

The five drums are mounted in a transfer housing 352 which, in use, is attached at its one end to the tipper, for example at mounting point 353. A support bracket assembly 354 is also provided to support the weight of the drums. The bracket additionally is attached to the tipper.

Referring now to Figure 23, there are shown only the major components of the transfer apparatus with many standard components omitted. The drums are driven from a single drive motor through top-hat shaped gear 356 attached to the drive shaft 358 of the receiving drum. A housing 360 is arranged over the drive shaft and a suction housing 362. The suction housing is retained in the receiving drum by a series of bearings and rings 362 and a bearing and seal retainer ring 364 to which the fluted portion of the receiving drum is attached. An end plate 365 is attached to the end of the drum.

It will be seen from Figure 23 that the gear 356 is a top-hat gear and that the inside mating surface around aperture 365 in the transfer housing which receives the drive shaft and the show housing has a spot face recess 366. The gearing and the spot face recess allow conventional components to be used with minimal modification. The housing 352 is sealed by a removable cover 368.

- 28 -

A back cutting plate 370, having apertures 372, 374, 376 is arranged on the front of the housing 352 so that upper aperture 372 and central aperture 374 overlie corresponding apertures 378, 380 in the housing for the intermediate and cutting drums respectively. The back cutting plate is positioned between the housing and the intermediate and cutting drums. All of the drums include suction housings to enable the rods to be held in their flutes. Suction housing 382 for the intermediate drum is received in location aperture 378 in the transfer housing 352 and the intermediate drum is arranged on the suction drum. A location ring 386 is provided to enable a conventional Max 80 receiving drum mounting to be used with the intermediate drum. The location ring is necessary as the Max 80 receiving drum is intended to be used with a variable height Hauni Spider, as a result of which the drum mounting plate, here the back cutting plate 370, is designed to pivot about the cutting drum. That plate is now fixed ensuring constant centres.

Suction housing 383 for the separation drum locates in location aperture 384 in the housing.

The drive for the receiving drum and the suction for all the drums are conventional and are not described here.

The arrangement of the flutes in the various drums is such that the rods pass along the centre line of the transfer point. The use of chamfered or tapered flute leads of twice the normal width, and the accompanying reduction in the number of flutes, together with the increased length of receiving drum and the use of vacuum holes along the entire length of the flutes results in a transfer apparatus that can reliably transfer double length rods using a kicker rather than a spider.

The tipper is shown schematically in figure 26. This diagram also shows elements of the transfer apparatus which have the same reference numerals and will not be described again. The tipper 400 includes a hopper

- 29 -

402 which holds a reservoir of filters for supply to the filter drum. The filter hopper may be fed manually from trays or automatically from automatic trays or from a plug shooter. The filter rods in the hopper may be of four or the six up configuration, that is four filter tips per rod or six filter tips per rod which means they will be cut into two or three double length rods to be inserted between the separated single length rods on the separating drum. Thus each six up filter rod will eventually provide the filters for six cigarettes. The filter rods are deposited into the grooves of a filter cutting drum 404 from the hopper where they are cut by knives into two or three double length filters which are inserted between the cigarette rods on the filter drum.

The tobacco rods are joined to the filters by tipping paper which is supplied from a bobbin 408 which is loaded manually on to the tipper. The tipping paper is drawn from the bobbin by a tension roller 410. The bobbin has a free end which is fed into a splicer unit. Splicing of the full bobbin onto the end of an expended bobbin is carried out automatically. As a consequence the machine does not have to stop to replenish bobbins. Loading of the bobbins is manual.

The tipper also includes a gluing unit 412 which supplies glue from a reservoir to the tipping paper which is then cut into single length strips by an arrangement of 11 or 8 knives. Individual glued strips are then fed on to the rod-filter-rod combinations on the swash plate drum. A heated rolling block is then used to wrap the tipping paper around the rod/filter tip combinations and to set the adhesive to make a double length cigarette. The double cigarette is then cut though the centre line of the filter to form two single length cigarettes which are opposed. The cutting drum includes a rejection port through which can be rejected rod pairs in between which no filter has been inserted. Also rejected are tipped cigarettes which include the cigarette wrapping paper

- 30 -

splice or the filter tipping paper splice. The finished cigarettes on one side of the machine are passed to a turning drum which reverses the cigarettes so that all the cigarettes are facing the same direction. This facilitates further processing.

After the tipping unit, the finished cigarettes are passed to an inspection unit which comprises an inspection drum where the cigarettes are subjected to a leakage test to check for holes or imperfections in the paper. This test is carried out by blowing compressed air through the cigarette and measuring the pressure drop across the cigarette. The compactness of the cigarette and the presence of a filter is checked, for example, by an optical or capacitance sensors. Any rod that fails either of these tests is rejected and ejected off the inspection drum. As an optional additional test dilution tests may be made to test the effectiveness of the attached filter to allow air to be drawn through its side perforations. After the inspection drum, cigarettes that have not been rejected are passed downstream to a tray filler or other processing unit which does not form a part of the present invention.

Conventional rod makers and tippers are driven from a single drive from which are taken a variety of secondary drives through appropriate reduction gearing. This is very bulky and inflexible. The combined rod maker and tipper embodying the present invention dispenses with that arrangement and uses a number of separate drives which are interconnected and controlled by a dedicated motion controller. The rod maker and tipper are controlled by the same PLC controller.

Figures 27, 28 and 29 show, respectively, the location of the principal motors in the rod maker and the tipper respectively. Tables 1 and 2 below show, respectively, the listing and function of each motor in the rod maker and the tipper.

- 31 -

<u>Motor</u>	<u>Function</u>
M2	Large Fan Motor
M3	Small Fan Motor
M4	Oil Pump Motor
5 M6	Hopper Motor
M8	Tobacco Return (vibrating tray) motor
M9	Cut-off cooling fan
M10	Cut-off cooling fan
10 M10.1	Cut-off cooling fan
M11	Control cabinet cooling fan
M12	Hopper Tangential Feeder motor
M14	Hopper Tobacco Delivery Roller motor
15 M15	Bobbin changer Capstan motor
M17	Weight control motor
M19	Tipper dust extractor
M21	Cut off motor(master for motion control) - drives cut-off knife drum
20 M22	Ecreteur motor (position synchronised) - drives dense end cam and ecreteur discs
25 M23	Printer motor (position synchronised) -drives print die wheel
M24	Tape drum motor (velocity synchronised) -
30 M25	drives garniture tape drum Suction chamber motor(velocity synchronised) - drives suction tape
M26	Hopper motor (velocity synchronised) - drives hopper carded drums
35	

- 32 -

Table 1: Rod Maker Motors

- 33 -

	<u>Electrical Reference</u>	<u>Motor Description</u>	<u>Motor Function</u>
	Tipper main drive motor (TMDM)	Position Synchronised to Cut off motor	Drives complete tipper gear train
5	M3	Bobbin Swivel	Swivels the bobbin plate
	M4	Glue Stirrer	Provides drive for glue rollers
	M5	Glue Pump	Glue feed
10	M7*1	Fan	Provides Suction for tipping drum
	M9*1	Vacuum Pump	Drives knife 1 (filter)
	M9*2	Knife 2	Drives knife 2 (tobacco rod)
15			

Table 2: Tipper motors

It should be appreciated that although the system has been described in terms of servo motors, non-servo motors could be used as some degree of control can still be achieved using a conventional variable speed motor with a speed control signal. Alternatively, motors using embedded intelligence may be used to provide synchronisation.

Referring now to figure 29 the positioning of the motors referred to in Table 2 can be appreciated. The main drive motor can be a synchronous servo motor. The other motors on the tipper are standard fixed speed motors. Figures 27 and 28 show the equivalent situation for the rod maker although some of the motors are omitted for clarity.

A preferred embodiment of the control system comprises the following main elements:

1. The machine controller;
2. The motion controller and servo motors;
3. The fieldbus connecting sensors, pneumatic valves and some motor drives to the machine controller;

- 34 -

4. The HMI; and
5. Inspection and rejection.

The machine controller comprises two PCs running the Windows NT (TM) operating system and configured such that one is a server and the other a client. Other operating systems such as WIN CE may be used. The PCs communicate via TCP/IP and Ethernet. The controller software controls both the maker and the tipper using standard PLC functions but without a PLC. The PCs communicate with the machine devices via the fieldbus.

The motion controller and servo motors provide synchronised control of servo motors on multiple axes by an advanced motion controller. Each axis is programmable for motor characteristics, speed, position and phase relationships. Synchronisation between motors relies on high speed communications between each axis controller which is independent of the fieldbus.

The fieldbus connects devices and I/o terminals to the machine controller via a single cable. Sensors attach either directly to the fieldbus cable or to connector blocks on the cable. Pneumatic valves may be attached to the fieldbus via their own interface in their valve island block and other motor drives and the motion controllers connect directly to the cable.

The HMI provides an easy to use, graphical interface for the operation, maintenance and configuration of the machine. In a preferred embodiment it uses a touch screen for operator command entry. The HMI provides on screen buttons, sliders, keyboards etc. for input of data and commands to the machine, as well as on-screen messages, gauges, digital displays, graphs, reports etc. to provide information to the operator. It also includes a database for multi-language messages and for historical records.

Inspection and rejection systems are controlled by an independent, dedicated programmable controller which interfaces to the machine controller and HMI for parameter settings and performance display.

- 35 -

The motion control, fieldbus and HMIs aspects of the control system will now be described in greater detail.

Motion Control. It will be appreciated that the synchronised servomotors are all synchronised to the cut off motor M21 which is the master for motion control. Alternatively, 5 synchronisation may be to a virtual axis. The relationship between garniture belt speed and the cut-off motor speed determines the length of the cut tobacco rod. The ecreteur and printer motors are speed and position synchronised with the cut-off motor and the tipper main drive motor is position 10 synchronised with the cut-off motor. The Tape drum motor, the suction chamber motor and the hopper motor are speed synchronised with the cut-off motor.

In conventional making machines, these motors have been 15 fixed by complex arrangements of gear boxes, shafts, drive belts etc. to support the various main functions controlling the product. By using a motion control system, the one main drive motor and associated drive system may be eliminated. Instead, a number of drives axes are used as the optimum solution between a 20 totally mechanical and totally electrical system. It will be appreciated from tables 1 and 2 that the preferred embodiment has 7 axes, 6 in the maker and 1 in the tipper. Of course, other numbers are possible and other motors may be introduced on 25 separate axes. Use of motion control has the obvious advantage of eliminating some costly gearboxes, but also reduces maintenance, reduces build time and reduces noise. This is especially important in the context of increasing production speeds. Furthermore, motion control allows the phase relationship between 30 the various axes to be used as an alternative to mechanical settings to give much more accurate results in much less time. It allows almost infinite tuning of the relationship between the axes. For example, the mechanical relationship of the tipper catching drum to the cigarette maker is greatly simplified. Moreover, the relationships between the various axes can be 35 varied dynamically. Thus in the example given above, the phase relationship of the catcher drum could be varied according to the machine speed to ensure optimum transfer. A further advantage is

- 36 -

the ability to change rod length without changing parts. Usually
a change in rod length would signify a change to production of a
different brand. This requires a different label to be printed
onto each rod. The print label could be changed electronically
5 using ink jet printing techniques and the relative position on
the rod as well as the rod length can both be adjust by varying
the relationships between the axes under motion control.

The motion control comprises the seven motors identified
earlier each with a motor controller mounted on a backplate with
10 a dedicated processor. The control could alternatively be
embedded in the motor. The processor is programmed to
synchronise and phase control the motors via their individual
controllers and information on phase and speed is fed to the
motion processor via a dedicated high speed transmission line.
15 As will be explained, the motion controller may also be connected
to the field bus so that it can receive control signal such as
stop, start, jog etc. and parameter signals such as speed, phase,
etc. and can send status signals to the system. The other motors
which do not form a part of the motion control system are
20 connected to the fieldbus either via their controllers or via
their direct on-line starters.

Fieldbus. The fieldbus consists of a cable routed around
the maker and the tipper to form the backbone of the control
system. The controllers and the controlled elements connect to
25 this cable. The flow of signals is controlled by a software
protocol. The presently preferred protocols are DeviceNet (TM)
and Profibus (TM). This protocol controls signal flow between
elements connected to the fieldbus to enable specific signal to
be routed to and from specific devices. In the DeviceNet
30 protocol, each signal is a packet containing 8 bytes of data.
The packet is preceded by a header which contains information
about the content of the message and its priority. Other devices
on the fieldbus will be programmed to certain message contents
35 and so will accept or not the message depending on the content of
the header. The priority content ensures that only one device
transmits at a time. In this way the control system may be
configured such that a central controller, typically a PLC or a

- 37 -

PC may control all functions or may be configured such that no central controller exists and intelligent devices communicate with other intelligent devices using peer to peer communications; these devices then perform the control functions related to their own applications.

The devices connected to the fieldbus may be similar to conventional devices with the addition of a processor whose function is to code information for transmission and to decode message the device needs to receive. Thus, for example, a switch would need to transmit information as to whether it is operated or not and possibly diagnostic information such as whether its operating surface is dirty, whether it is overheating, is receiving too much vibration etc. On the other hand, a motor could transmit information such as speed, torque, direction of rotation, power temperature etc. The motor may also receive information such as start, stop, jog, change speed or direction etc. Devices that do not have the necessary processor embedded may still be connected to the fieldbus but will require an interface which will handle coding and decoding. Of course in that case, the device cannot produce diagnostic information.

Figure 30 shows an overview of a first embodiment of the control system. A field bus 500 connects six main system blocks: the maker 502, the maker cabinet 504, the tipper 506, the tipper cabinet 508, the inspection unit 510 and the control system 512. The maker block includes the maker HMI 514, a number of blocks of sensors, here shown as sensor blocks 516, 518 and 520, and a block of pneumatic valves 522. Each of the sensor blocks, the valve blocks and the HMI are connected to the fieldbus 500. The maker cabinet 504 has a number of variable speed drives and a maker machine controller each attached to the fieldbus. In the figure, variable speed drives 524-530 are shown for the picker/winnower, large and small fans and tobacco return. In the tipper, the tipper HMI 532 is connected directly to the fieldbus as are drives block sensors 534, glue area sensors 536, pneumatic valve clutches 538 and pneumatic auto cleaning valves 540. In the tipper cabinet, the tipper machine controller 542 is connected to the fieldbus 500. In the inspection unit, a

- 38 -

DeviceNet scanner 544 is connected to the fieldbus. Connected to the Scanner 544, which acts as an interface, is an inspection and rejection controller 546.

A DeviceNet manager 548 is also connected to the fieldbus.
5 Of course, this manager is chosen according to the fieldbus protocol being used. Finally a central controller 550 is also connected to the fieldbus. This central controller 550 has overall control over all machine functions over the fieldbus.
10 The central controller 550 has VGA, keyboard and mouse inputs 551, which are also attached to a further PC 552 for programming input and to a data capture device 554 which is connected to the DeviceNet manager 548 via a local Ethernet 556.

The synchronous motor motion controller 557 is connected to the central controller 550 via a remote I/O link 558. It will be appreciated that the motion controller is not connected to the fieldbus. Thus, for example, operating parameters input via the HMIs, which themselves may be accessed remotely are received first by the central controller which can send them to the motion controller if appropriate. Control of speed and phase of the synchronised motors is therefore separate from the HMI functions.
20

Figure 31 illustrates an alternative control arrangement. In this figure the two HMIs, shown as operator control touch screens 560, 562 are connected by a graphics cable link to the central machine controller 564 and are kept remote from the fieldbus or control network 566. Although one of the HMIs 560 is shown dissociated from the maker cabinet, there is still one HMI for the maker and one for the tipper. The machine controller is connected to management supervisory systems 568 and to the factory network 570 via an Ethernet link. In the maker and tipper cabinets, the valves and various I/O devices are all connected to the control network before. However, in addition, the motion controller 572 is also connected to the control network. It will be appreciated that the HMIs are still separated from the motion control by the overall machine controller 564. In figure 31, a representative selection of maker functions are shown connected to the control network. This is not exhaustive.

- 39 -

5 HMI. Two HMIs are required providing different functions, one for the tipper and one for the rod maker. This gives rise to the need for two PCS. The PCS are configured such that the database and one HMI process reside on the server PC and the other is configured as a client.

10 The HMI software, in addition to displaying machine control and message functions allows the integration of other PC applications for historical data analysis, performance reports to networked PCS or systems and on line diagnostic and help facilities such as parts catalogues, operator manuals, expert systems and operator training videos.

15 The HMI uses open technologies to allow maximum connectivity and use of technologies such as the Internet and Object based programming. This may be utilised to connect to other applications within the factory for maintenance tracking and to a central parts supplier for predictive maintenance and parts ordering. Other applications are, of course possible and will occur to those skilled in the art.

20 A separate HMI is provided on both the tipper and the rod maker although a single HMI could be used. The HMIs are each controlled by a PC which may be connected through a TCP/IP link for example to a remote LAN. This gives rise to the possibility of accessing the controllers of the tipper and the rod maker from a remote location possibly not even in the factory. The HMIs provide the system supervisor with a software interface to the cigarette making machine. The HMI displays comprise a configurable selection of function buttons, which may be displayed on, for example, a touch sensitive display screen. An operator can input a password from a keypad which will give access to one of a hierarchical set of control levels. For example a master password gives complete access to the system whereas a more restricted access may only allow the user access to certain control functions. As an alternative to a keypad, passwords or user identifiers may be stored on swipe cards or other identification devices and the HMI provided with a suitable card reader.

- 40 -

The HMI may be implemented as a PC with a suitable interface to the machine controller.

Figures 32 to 36 show examples of HMI screens which are presented to the operator. Many of the user selectable features are represented as push buttons. These are areas of the screen which perform a function equivalent to a push button when selected by the operator. As can be seen from the shading of the buttons shown in the figures, different types of function may be displayed as different coloured buttons. For example, each of the following functions may be represented by a different colour:

5 change to another screen; stop a function that is presently running; start a non-running function; inching (very slow movement of a component such as a motor; fault reset; and miscellaneous. At any given time, the HMI will only display to the operator a fraction of the available information, or the available controls. Figure 37 shows the relationship between various different screens which could be presented to an operator with the appropriate level of clearance. It will be clear to those skilled in the art that figure 37 only shows a few of the 10 screens which could be displayed.

15

20

The screen shown in figure 32 is the main menu. The information is presented on four rows. The first row 420 is for message display. In figure 32 this informs the operator that the machine is stopped having detected a fault in the roll block heater which is outside its preset operating range. The message row would also display the machine speed in cigarettes per minute if the machine was running.

25 The second row has only a FAULT RESET button 422 by which the operator resets the machine after a fault has been cleared. The third row has a STOP button 424, selection of which causes the machine to come to a controlled stop; and a SUCTION CHAMBER GUARD 426.

30 The fourth row has, from left to right, the following buttons:

35

PREPARE MAKER 428
PARAMETER ADJUST SCREEN 430
PHASE SHIFT SCREEN 432

- 41 -

MAINTENANCE MODE SCREEN 434
ADVANCED DIAGNOSTICS SCREEN 436
GO TO CONFIG SCREEN 438

The PREPARE MAKER button 428 selects the prepare maker screen shown in figure 33. The PARAMETER ADJUST SCREEN button 430 selects the parameter adjust screen shown in figure 34. Selecting the PHASE SHIFT SCREEN button 434 takes the operator to a phase shift screen shown in figure 35. Selecting the MAINTENANCE MODE SCREEN button 434 takes the operator to a maintenance mode screen and selection of the ADVANCED DIAGNOSTICS SCREEN and GO TO CONFIG SCREEN buttons 436, 438 takes the operator to advanced diagnostics and go to configuration screens respectively.

Turning to figure 33, the first row of the prepare maker screen is similar to that of the main menu but additionally includes a display of the present heater temperature. On the second row, in addition to the FAULT RESET button are MAKER FANS, TOBACCO FEED, HOPPER and GARNITURE TAPE buttons 440, 442, 444 and 446. Each of these four buttons turns the respective item on or off when selected. The third row of the screen has, in addition to the suction chamber guard button displayed on the main screen, ROD HEATER ON, HEATER DOWN, MANUAL GLUE and SUCTION CHAMBER TENSION buttons, 448, 450, 452 and 454. The ROD HEATER on button switches on the rod heater and the HEATER DOWN button brings the heater down allowing lap and heater settings to be checked. The MANUAL GLUE button switches the glue supply on and off and the SUCTION CHAMBER TENSION button allows the suction tape tensioner to be switched on and off. When off, the tape can be removed and changed. The SUCTION CHAMBER GUARD button turns the suction chamber guard on and off.

The fourth row of the prepare maker screen has a MAIN MENU button 456 which returns to the main menu, and buttons 458, 460 RUN MAKER IN MANUAL and RUN MAKER IN AUTO which take the operator to manual/automatic running screens (not shown). The RUN MAKER IN MANUAL button will only operate if the software detects that the MAKER FANS button 440 is on, and the RUN MAKER IN AUTO

- 42 -

function will only operate if the MAKER FANS, TOBACCO FEED and HOPPER buttons are in an on position.

The PARAMETER ADJUST screen is shown in figure 34. This allows the operator to adjust certain parameters of the rod maker from the HMI simply by pressing the relevant areas on the screen. The information on the PARAMETER ADJUST screen is divided into five rows. On the first row are buttons INCH SPEED, MAKER HEATER and CIGARETTE LENGTH 462, 464, and 466, for adjusting the inch speed, the temperature of the maker heater and the cigarette length respectively. On the second row are buttons LOW SPEED, HEATER MAKER STOP HIGH LIMIT and MAKER HOPPER SPEED 468, 470 and 472 for setting low running speed (in cigarettes per minute), for automatically stopping the maker heater when the temperature reaches the set level, and for setting the hopper speed. On the third row are buttons 474, 476 PRODUCTION SPEED and MAKER HEATER STOP LOWER LIMIT for setting production speed and the lower limit of the maker heater. The sole button 478 on the fourth row MAINTENANCE SPEED sets the machine speed for running during maintenance operations. On the fifth row, the sole button 480 PREVIOUS SCREEN returns the user to the previous screen.

Figure 35 shows the phase shift screen. This display has four rows of buttons, the first two of which perform self explanatory functions. On the first row are PRINTER ADVANCE, ECRETEUR ADVANCE and TIPPER ADVANCE buttons 482, 484 and 486. On the second row are PRINTER RETARD, ECRETEUR RETARD AND TIPPER RETARD buttons 488, 490 and 492. On the third row is a PHASE ADJUST button 494 which allows the operator to select the amount by which the selected axis from one of the first two rows is adjusted. Typically the adjustments will be in increments of 0.1mm. The fourth row has PREVIOUS SCREEN and STOP buttons 496 and 498.

The screens illustrated are all examples of maker HMI screens. It will be understood that the tipper HMI displays similar screens as appropriate to the tipper functions. The PREPARE TIPPER screen is shown at figure 36.

Figure 38 is a flow chart which explains the major control steps of the controller. The controller, which is separate from

- 43 -

the HMI may typically be a PC using control software applications running under Microsoft Windows NT, or a display panel.

On initialisation, once the controller has established that the machine is ready to start (at 700), the controller performs a 5 start up routine at 702 and then actively monitors the cigarette production speed at 704. The production speed may be input through the HMI with other production data such as tobacco rod length, tobacco density and print position. In practice, most of these variable are fixed for a given brand of cigarettes and the 10 operator can simply enter through the HMI the brand of cigarette to be manufactured. The combined tipper and rod maker described can operate at speeds of up to 8000 cigarettes per minute (cpm).

At any time during production, the operator can stop the machine. At step 706, the controller looks for an indication of a manual stop and if one is detected stops production and causes 15 that information to be sent to the HMI for display. The controller then keeps looking for a reset command which, when received causes the controller to return to the beginning of the control process. At Step 708 the controller monitors the data on the fieldbus for an emergency stop signal which may be received from one of the devices on the fieldbus, for example in the event 20 of an actual, or impending catastrophic failure of a component. At step 710 the controller monitors the data on the fieldbus for an indication of a fault condition. In either steps 712 or 714 25 the controller will cause production to be halted and look for a reset command in the same manner as with a manual stop.

The smart devices plugged into the fieldbus may be capable 30 of distinguishing between a condition which requires the production line to be halted and a fault which requires fixing when convenient. At step 716, the controller looks for warning signals put on the fieldbus by any of the devices and relays this warning to the HMI, for example to be displayed, printed or otherwise drawn to the operator's attention. At step 718, having failed to find any reason that requires the production to be 35 stopped, and after any warning messages have been sent to the HMI, the controller at steps 720 and 722 looks for information from sensors located at the wrapper paper bobbin and the tipping

- 44 -

paper bobbin to determine whether either of the bobbins need to be changed. If one does, the controller checks to see that a fresh bobbin is present and then, at step 724 or 726, runs the appropriate splice routine which will involve controlling the speed of the bobbin to gradually bring it up to the manufacturing speed while monitoring the condition of the paper reservoir.

At step 728, the controller looks to see whether there is data on the bus from the HMI and, if so, acts on it and communicates that fact to the HMI. At step 730 the controller sends data on the fieldbus to the HMI that does not fall into the categories described above and which might be required, for example operating data such as running speeds, output rates, reservoir levels, temperatures etc.

Figures 39, 40 and 41 are flow charts of the start up process and help to understand how the HMIs and the control PCS interact. When the operator begins the start up routine at step 900, the software first checks at step 902 that all emergency stops on the system are unlocked. Then at step 904, it checks that all guards and covers on the tipper and the maker are closed. At step 906 it checks that the compressed air supply is on and at step 908 and 910 it checks that the appropriate maintenance and cleaning schedules have been followed. Finally at step 912 the main isolators are checked and if on, the software enters the tipper start procedure at which point the operator selects the prepare tipper screen of figure 31. The tipper start procedure commences by checking, at 914 and 916, that the glue supply and tipper paper are in order. If they are, the operator selects from the HMI screen, at steps 918, 920, 922, 924, 926 and 928, the ROLL BLOCK, TIPPER FANS, GLUE ROLLER, KNIVES MOTOR, AUTO/MANUAL and INCH to turn each function on and select between automatic and manual operation. The INCH function will advance the tipper until it is determined, at 930, 932, that the tipper paper feed is in the correct position and the filter plugs are on the feed drum. At that point the software can proceed to the maker start routine illustrated in figure 35. The operator initially selects the display language at the HMI, at 934 and then presses, at 936, the prepare maker screen from the

- 45 -

main display. On the prepare maker screen, the operator then
switches on the maker fans, the tobacco feed, and the hopper at
steps 938, 940 and 944. At 946, the operator loads the bobbin
with paper and threads the paper through the printer and then, at
5 948, selects INCH from the HMI display whereupon the drives are
slowly moved round until the software detects that tobacco is
available at 950 at which point paper is fed along the garniture
and the print lever engaged at 952. When it is found that all
10 materials are feeding correctly, at 954, the operator can select
at 956 the RUN MAKER IN AUTO button from the prepare maker screen
and the run automatically from the AUTO RUN screen.

The cigarette rod maker and tipper described, and the
method of control have a number of advantages over prior art
systems. The use of synchronous drive motors eliminates the need
15 for noisy inefficient gearboxes running off a central motor
facilitating an increased running speed. Moreover parameters such
as print position, and dense end position can be moved as a
control operation related to the printer or cam phase. This
means that these parameters can be adjusted with reduced
20 production stoppage time. This results in an improvement in
quality which can reduce production costs. As well as giving
higher operating speeds, the use of synchronous servo motors is
much less noisy which contributes to a more benign working
environment. In addition the energy requirements are much lower.
25 A further advantage of the system is that by dispensing with a
greater part of the mechanical linkages, the mean time between
failures is increased. The use of a PC based HMI and smart
sensors and other devices also reduces the mean time to repair as
diagnostics information is available at the HMI. The HMI can
30 also identify the particular component which requires replacing
by use of an on-line catalogue. This in turn can reduce the size
of inventory that has to be carried. As the HMI can be connected
by a TCP/IP link to an Intranet or LAN, remote diagnostics are
possible as well as remote repairs and upgrades. In addition,
35 factory data can be downloaded from a central source to one or a
number of machines. This, may include information such as master
clock, shift times, brand data etc. Furthermore, the HMI can be

- 46 -

programmed to carry instructional information which can be used to inform operators, for example, about aspects of the machine control which they would rarely encounter, or to run interactive training programs, for example on CD-ROM or training videos for new operators.